



(11) **EP 2 677 593 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
25.12.2013 Bulletin 2013/52

(51) Int Cl.:
H01M 10/50 (2006.01) H01M 2/10 (2006.01)

(21) Application number: **11858862.3**

(86) International application number:
PCT/JP2011/079102

(22) Date of filing: **15.12.2011**

(87) International publication number:
WO 2012/111231 (23.08.2012 Gazette 2012/34)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **16.02.2011 JP 2011031005**

(71) Applicant: **Nissan Motor Co., Ltd
Yokohama-shi, Kanagawa 220-8623 (JP)**

(72) Inventor: **NAGASHIMA, Tomio
Atsugi-shi, Kanagawa 243-0123 (JP)**

(74) Representative: **Hager, Thomas Johannes
Hoefer & Partner
Patentanwälte
Pilgersheimer Strasse 20
81543 München (DE)**

(54) **CELL CASE, AND STRUCTURE FOR ATTACHING CELL CASE**

(57) [Problem] To provide a cell case, which maintains cell temperature low by reducing heat reception during the time of non-use (at no power generation), while ensuring heat dissipation performance during use (when generating power), and which is capable of suppressing reduction of cell capacity due to thermal degradation, and to provide a structure for attaching the cell case.

[Solution] A cell case (100) has a sealed structure, and houses a battery module (180) having at least one cell (182). The cell case has a supporting mechanism (140) for supporting the battery module (180), and which forms a space (S) between the outer surface of the bat-

tery module and the inner surface of the case; a first cover layer (184), which has a radiation emissivity larger than that of the outer surface of the battery module, and which is disposed on the outer surface of the cell module; and a second cover layer (124), which has a radiation emissivity larger than that of the inner surface of the case, and which is disposed on the inner surface of the case. The first cover layer (184) and the second cover layer (124) are opposed to each other at least partly through a space (S).

EP 2 677 593 A1

Description

Technical field

[0001] The present invention relates to a cell case and a mounting structure for cell case.

Background art

[0002] To ensure insulating properties when submerged, although various cell cases of sealed structure have been proposed, it has been the issue to suppress capacity loss due to thermal degradation (reduction of cell life) of the cell accommodated inside. The radiation performance has been improved for the cell which becomes hot due to heat generated during power generation by providing fin structure outside the housing (e.g., refer to Patent Document 1), conducting heat to a metal plate of the housing (e.g., refer to Patent Document 2), or making the outer surface of the housing to be of high emissivity (e.g., refer to Patent Document 3).

Prior art documents

Patent literature

[0003] Patent Document 1: JP 2004-304881 A
Patent Document 2: H 10-333782
Patent Document 3: JP2008-130729

Summary of the invention

Problems that the Invention is to Solve

[0004] However, despite the radiation performance being secured during use (power generation), a cell case is subject to be heated in an unused state (non-power generation state) in the daytime by receiving heat at high outside air temperature. The cell temperature consequently rises and thermal degradation occurs. Specifically, when the cell temperature in unused state is higher than the outside air temperature, it is difficult to suppress to receive heat from outside so that there has been a problem that the cell capacity decreases despite non-use of the cell.

[0005] The present invention has been made in order to solve the problems associated with the prior art described above, while ensuring the heat dissipation performance during the use (power generation), to reduce the heat receiving during a unused time (non-power generation) and to provide a mounting structure to the battery case so as to maintain a low cell temperature in which the cell can be suppressed from lowering the capacity due to the thermal degradation.

Mechanism for Solving the Problems

[0006] One aspect of the present invention for achiev-

ing the above object is a sealed cell case which houses or accommodates a cell module or battery module having at least one cell. The battery module comprises a supporting mechanism for supporting the battery module, thereby forming a space between the outer surface of the battery module and inner surface of the case, a first cover layer disposed on the outer surface of the battery module and having a higher thermal radiation coefficient or emissivity than that of the outer surface of the battery module, and a second cover layer disposed on the inner surface of the case having a higher radiation coefficient or emissivity than that of the inner surface of the case. The first cover layer and the second cover layer are opposed to each other at least partly through the space.

[0007] Another aspect of the present invention for achieving the above object is a mounting structure to the battery case of sealed structure that accommodates a battery module having at least one cell or battery, wherein the battery case comprises a supporting mechanism for supporting the battery module, thereby forming a space between the outer surface of the battery module and inner surface of the case, a first cover layer disposed on the outer surface of the battery module and having a higher thermal radiation coefficient or radiation emissivity than that of the outer surface of the battery module, and a second cover layer disposed on the inner surface of the case having a higher radiation coefficient or radiation emissivity than that of the inner surface of the case. The first cover layer and the second cover layer are opposed to each other at least partly through the space. In addition, the battery module has a pair of opposing surfaces opposed to each other and a wall surface which connects the pair of opposing surfaces, wherein the first cover layer is disposed on at least one of the pair of opposing surfaces, and the supporting mechanism is provided on the wall surface. Also, with respect to the direction of gravity, the one of the pair of the opposing surfaces is positioned above while the other of said pair of opposing surfaces is positioned below so as to be attached to the battery case.

[0008] Still another aspect of the present invention for achieving the above object is a mounting structure to the battery case of sealed structure that accommodates a battery module having at least one cell or battery, wherein the battery case comprises a supporting mechanism for forming a space between the outer surface of the battery module and the inner surface of the case, a first cover layer disposed on the outer surface of the battery module and having a higher thermal radiation coefficient or radiation emissivity than that of the outer surface of the battery module, and a second cover layer disposed on the inner surface of the case having a higher radiation coefficient or radiation emissivity than that of the inner surface of the case, wherein the first cover layer and the second cover layer are opposed to each other at least partly through the space. In addition, the battery module has a pair of opposing surface portions opposed to each other and a wall surface which connects the pair of opposing

surfaces, wherein the first cover layer is disposed on one of the pair of opposing surfaces. Also, with respect to the direction of gravity, the one of the pair of the opposing surfaces is positioned above while the other of said pair of opposing surfaces is positioned below so as to be attached to the battery case.

[Effects of the invention]

[0009] According to the present invention, because the outer surface of the battery module and the inner surface of the case respectively have a cover layer of radiation coefficient or emissivity higher than the emissivity of the associated base material, the heat dissipation at a high temperature is improved and the dissipation properties of the battery subjected to high temperature due to power generation will be secured. In addition, because of a space provided between the outer surface of the battery module and the inner surface of the case for reduction of heat receipt, the increase in battery temperature by a heat receiving during non-power generation where the ambient temperature is higher than the battery temperature in the daytime. Therefore, by securing dissipation performance during use (i.e. power generation) while reducing the heat receipt or absorption during non-use (i.e. non-power generation), such a battery case or an attachment structure for the battery case may be provided which maintains the battery temperature low and may suppress reduction in battery capacity due to thermal deterioration or degradation.

[0010] By reference to the preferred embodiments illustrated in the accompanying drawings and the following description, other objects, features and characteristics according to the present invention will become more apparent.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Figure 1 is a cross-sectional view for explaining a battery case of an embodiment according to the present invention.

Figure 2 is a conceptual diagram for explaining the radiation heat transfer in the embodiment according to the present invention.

Figure 3 is a perspective view for explaining an arrangement of the first cover or coating layer shown in Figure 1.

Figure 4 is a diagram table indicating first to fourth embodiments as well as first and second Comparative examples showing measured values of thermal transmittance at the time of receiving ambient heat. Figure 5 is a diagram table indicating first to fourth embodiments as well as first and second Comparative examples showing measured values of thermal transmittance at the time of high power output. Figure 6 is a diagram table indicating first to fourth

embodiments as well as first and second Comparative examples showing measured values of temperature at the time of high power output.

Figure 7 is a diagram table indicating first to fourth embodiments as well as first and second Comparative examples showing heat dissipation properties. Figure 8 is a cross-sectional view for explaining a dummy cell or battery module.

Figure 9 is a cross-sectional view for explaining Comparative Example 1

Figure 10 is a cross-sectional view for explaining the Comparative Example 2.

MODE FOR CARRYING OUT THE INVENTION

[0012] In the following an embodiment of the present invention will now be described with reference to the drawings,

[0013] Figure 1 is a cross-sectional view for explaining a battery case according to an embodiment of the present invention, and Figure 2 is a conceptual diagram for explaining the heat transfer radiation according to the embodiment of the present invention.

[0014] A battery case battery 100 pertaining to the embodiment of the present invention is shaped substantially rectangular, is provided with a case body 120 of recessed shape for receiving a battery module 180, a bracket as supporting mechanism of the battery module 180, and a lid portion 160 to form a closed structure, and is used as a power source mounted on the vehicle 190 for example.

[0015] The battery module 180 is shaped generally rectangular, and is configured to be composed of a plurality of containers 182 arranged juxtaposed, each accommodating a plurality of cells 182. By connecting the cells 182 in parallel or serial, a battery pack be formed corresponding to a desired current, voltage or capacity. For example, cell 182 is a flat-type lithium ion secondary battery.

[0016] Bracket 140 forms a space S between the outer surface of the battery module and the inner surface of the case through an indirect supporting or fixing structure such that the heat-receiving property of the inner surface of battery case (cell) with respect to the heat from the outer surface of the battery module (ambient air) is reduced. Therefore, the increase in battery temperature due to the heat-receiving is prevented during non-power generation in the daytime where the ambient or outside temperature (30 °C, for example) is higher than the temperature of the battery (20 °C, for example) such that thermal degradation of the battery 182 during unused time (at non-power generation) is suppressed.

[0017] On the outer surface of the battery module is disposed a first cover layer 184 with a radiation coefficient or emissivity higher than that of the outer surface of the battery module while on the inner surface of the case is disposed a second cover layer of radiation coefficient or emissivity higher than that of the inner surface of the case. The first cover layer 184 and the second cover

layer 124 are opposed to each other through the space S. The first coating layer having an emissivity higher than emissivity of the outer surface of the battery module is disposed on the outer surface of the battery module, the inner surface of the case, the second coating layer having emissivity greater than the emissivity of the inner surface of the case 124 is located. And the second coating layer 124 and the first coating layer 184 has opposed through the space S.

[0018] As described above, since the battery module 180 is supported (indirectly fixed) through bracket 140, the heat transfer between the battery case 100 and the battery module 180 is dominated by convective heat transfer and radiative heat transfer.

[0019] As shown in Equation 1 of Figure 2, the heat transfer q per unit area by convection heat transfer may be calculated by multiplying the heat transfer coefficient α_1 and the value obtained by subtracting the absolute temperature T space of the space S from the absolute temperature T_1 (surface) of the outer surface of the battery module. The heat transfer coefficient α_1 is in turn calculated by first multiplying $1/4$ power of the product of the Grashof number Gr and the Prandtl number Pr , the thermal conductivity λ of the space S, and 0.54, and subsequently dividing by the representative length of the heat transfer surface of the battery module 180. In other words, the amount of heat transfer q per unit area by convection heat transfer is linearly proportional to the difference between the absolute temperature, and the temperature dependence is thus relatively small.

[0020] On the other hand, as shown in equation 2 in Figure 2, heat transfer q per unit area due to radiation heat transfer is calculated by multiplying the Stefan-Boltzmann constant and a first value obtained by subtracting fourth power of the absolute temperature T_2 of the inner surface (surface) of the battery case from fourth power of the absolute temperature T_1 of the outer surface (surface) of the battery module, and then dividing this first value by a second value obtained by subtracting 1 from the sum of the reciprocal of the emissivity of the outer surface of the battery module ε_1 and the reciprocal of the emissivity of the inner surface of the battery case ε_2 . In other words, because the amount of heat transfer q per unit area by radiation heat transfer is calculated by the difference between the fourth powers of the absolute temperatures, the temperature dependence is large.

[0021] Because of the presence of the first and second cover layers 184, 124, respectively, due to greater emissivity compared to the substrate, in this embodiment the heat dissipation at a high temperature due to radiation heat transfer properties will be significantly improved. That is, the heat dissipation of the battery at high temperature, which is subjected to high temperature by heat generated during power generation is improved such that the heat dissipation performance during use (power generation) is ensured. For example, when the temperature of the battery rises by heat generated during power generation and exceeds the outside air temperature (for ex-

ample, 30 °C) and in accordance with increase in the temperature difference to the outside air temperature, the amount of heat transfer from the outer surface of the battery module to the inner surface of the battery case (cell) increases (in accordance with the difference of 4th power of temperatures) such that a sufficient amount of heat transfer by radiation may be achieved at the temperature of use (e.g., at 60 °C).

[0022] Thus, the battery case 100 is configured, as described above, to reduce the heat receiving properties at the time of non-use while ensuring the heat dissipation performance at the time of use (power generation) such that such a battery case 100 may be provided that may hold the battery temperature low and suppress the capacity loss of battery or cell due to thermal degradation of the battery 182.

[0023] Figure 3 is a perspective view explaining an arrangement of a first cover layer shown in Figure 1.

[0024] As the portions for the first cover layer to be disposed are assumed planes A to F disposed in the battery module 180. Surface A and the surface B represent a pair of relatively opposing surfaces. The surface A is a top surface located in the uppermost with respect to the direction of gravity, and the surface B surface is a bottom surface which is located in the lowermost with respect to the direction of gravity. Surfaces C to F are side wall surface that connects the plane A and plane B. Surfaces C and D represent a pair of supporting side surfaces opposing to each other and to which bracket 140 is fixed, and surfaces E, and F represent a pair of non-supporting side surfaces opposing each other and bracket 140 is not attached thereto.

[0025] Thus, when all the surfaces A to F (i.e. the entire surface of the outer surface of the battery module) are disposed with a first cover layer, and the entire surface of the inner surface of the battery case 100 is disposed by a second cover layer, since emissivity is improved over the entire surface of the inner surface of the case as well as the entire surface of the outer surface of the battery module, it is possible to maximize the heat dissipation when used in high temperature.

[0026] Further, when a first cover layer disposed on the side wall surfaces of the battery module, and with respect to the direction of gravity, the battery case is attached such that the one of the opposing surface portions is positioned above while the other one of the opposing surfaces is positioned below, that is, when surfaces C and D representing the supporting side surface of the battery module as well as the surfaces E, F of non-supporting side surfaces are applied with a first cover layer, since surfaces C to F represent the portions of maximum change in thermal resistance at high temperature with respect to that at low temperature surface, the effects per unit area of application is the highest. In addition, it is preferable to apply the first cover layer to the non-supporting side surfaces E, F, since that arrangement will be able to suppress interference with the heat dissipation performance due to the presence of bracket 140.

[0027] Further, when the one of the pair of the opposing surfaces in the battery module is applied with the first cover layer, and the one of the opposing surfaces applied with the first cover layer is positioned above while the other of the opposing surfaces positioned below with respect to the direction of gravity, to arrange the battery case, that is, when the surface A representing the upper surface of the battery module is applied with the first cover layer, since the surface A represents a portion of the highest temperature, the average temperature may be decreased and the temperature variation from portion to portion (surface to surface) can be reduced such that the effects per surface of the first and second cover layers will assume the highest.

[0028] Note that the first cover layer 184 and the second cover layer 124 are not limited to the identical shape and/or arrangement. For example, it is possible to be configured in such a way that these are opposed to each other at least partially or partly through the space S. In addition, battery case 100 and battery module 180 are not limited to a generally rectangular shape.

[0029] The first and second layers 184, 124 are formed by applying a coating material containing a high radiation and performing a baking process. As the high radiation materials, for example, an oxide composite represented by silica (SiO₂) or alumina (Al₂O₃), or a clay mineral such as kaolin may be enumerated. However, the first and second cover layers 184, 124 are not limited to these configurations formed by coating. For example, when the base material or substrate of the outer surface of battery module and the inner surface of the case is aluminum, by anodizing or chemical processing, forming of a high radiation cover film is possible. Further, it is possible to form the first cover layer 184 and the second cover layer 124 in different compositions or formed by different process.

[0030] With respect to bracket 140, the mounting form is not particularly limited, and may be disposed on each side surface, or placed on the top surface and the bottom surface, for example, as long as no influence would be exerted on heat transfer between battery case 100 and battery module 180 where heat transfer through heat conduction and heat radiation are dominant.

[0031] The lithium ion secondary battery has a power generating element, an exterior material for sealing the power generating element, and a tub (electrode terminal) derived to the exterior of the exterior material. Power generating element is formed by sequentially stacking a positive electrode plate, negative electrode plate and a separator, sequentially. For example, the positive electrode plate is formed by a positive electrode active material layer consisting of a lithium-transition metal composite oxide such as LiMn₂O₄. For example, the negative electrode plate has a negative electrode active material layer consisting of a carbon and lithium-transition metal composite oxide. For example, the separator is formed from porous PE (polyethylene) having an air permeability capable to penetrate the electrolyte.

[0032] From the viewpoint of weight reduction and thermal conductivity, the exterior material consists of sheet material such as a polymer-metal composite laminate film in which a metal (including alloys) such as aluminum, stainless steel, nickel, and copper is coated with an insulator such as a polypropylene film, and a part or entire periphery thereof is joined by heat fusion. However, the exterior material is not limited to the sheet material such as a laminate film, a metal case may be employed instead, however.

[0033] Now, description is made of a measurement result of heat radiation characteristics of the battery case 100 in the embodiment according to the present invention.

[0034] Figure 4, Figure 5, Figure 6 and Figure 7 show, with respect to first to fourth embodiments as well as first and second Comparative Examples, measured values of thermal transmittance at the time of receiving ambient heat. measured values of thermal transmittance at the time of high power output. measured values of temperature at the time of high power output, and heat dissipation properties, respectively. Figure 8 is a cross-sectional view for explaining a dummy cell or battery module. Figures 9 and 10 are cross-sectional views for explaining Comparative Example 1 and 2.

[0035] Battery cases having a dummy battery module pertaining to the first to fourth embodiments as well as the first and second Comparative Examples, are placed on an insulating material of column shape placed on a table within a room, output of the dummy battery module dummy is adjusted and left for a certain time for stable state to be attained, and temperatures on each of surfaces A to F are measured as measurement items. Based on the heat transfer coefficient calculated from the measurement temperatures, the heat radiation characteristics were evaluated. The heat transfer coefficient ($W / (m^2 \cdot K)$) is calculated by dividing a power density (W/m^2) by the value obtained by subtracting the outside air temperature (K) from the dummy cell module temperature (K) (see Equation 3 in Figure 4). Power density (W/m^2) is calculated by dividing output (W) by area (m^2) (see Equation 5 in Figure 4).

[0036] The dummy battery module 180A is an alternative to the battery module 180, and as shown in Figure 8, consists of a box made of aluminum with rubber heater 182A and the insulating material 186 disposed therein. By controlling a voltage using a variac, rubber heater 182A is simulated for heating state of the battery or cell. Flow rate of the outer surface of the battery module case 100 is assumed to be of a natural convection state assuming the vehicle stopped state in which ambient thermal resistance is maximized. The insulating material 186 is disposed to prevent heat generated in the rubber heater 182A to be transmitted to portions other than the outer surface of the dummy battery module 180A.

[0037] Set temperature are aimed at 40 °C assuming a low temperature region (i.e., ambient or outside temperature) at receiving heat from an outside air tempera-

ture and at 70 °C assuming a high power high-temperature region (between 70 to 80 °C) for high power output. Temperature were controlled by changing output value while holding the output of rubber heater 182A to be the same on each surface. The point in time at which the temperature has stabilized was set at the point at which the difference between temperature of the upper surface of dummy battery module 182A (surface A located in the uppermost with respect to the direction of gravity) and the outside air temperature assumed a steady-state value. This was intended to match the rate of heat dissipation with respect to the heat dissipation amount (output) of rubber heater 182A at each experiment since a part of heat amount generated by rubber heater 182A causes a rise in the temperature of the members that make up the dummy battery module 180A until reaching an equilibrium state.

[0038] Temperature measurement was performed by attaching a thermocouple to outer surfaces A to F of dummy battery module, inner surface of the battery case, and outer surface of battery case. In addition, the outside air temperature was also measured.

[0039] Now, description is made of the configurations of the first to fourth embodiments as well as the first and second Comparative Embodiments used for measurements of heat dissipation properties.

[0040] Except for the difference in surfaces to which the first and second cover layers are arranged or disposed, the first through fourth embodiments are substantially the same. The first and second cover layers are formed by applying approximately 30 μ m thickness of coating material for heat dissipation (Cooltech CT100 ©, Okitsumo Co.) and performing a baking process. Note that the first cover layer is disposed on surface C representing a supporting side surface in the first embodiment, on all surfaces A to F in the second embodiment, on surfaces E, F representing the non-supporting side surface in the third embodiment, and on the top or upper surface A in the fourth embodiment, respectively. The second layer is disposed to oppose the first cover layer.

[0041] Except that, as shown in Figure 9, the first and second cover layers are not disposed, Comparative Example 1 is substantially the same as the first to fourth embodiments. As shown in Figure 10, in the second Comparative Example, the bottom surface B is fixed to the inner bottom surface of the battery case tightly so that the heat dissipation through heat conduction is dominant.

[0042] Now description is made of the evaluation results of heat dissipation characteristics.

[0043] As shown in Figure 7, the evaluation of heat dissipation characteristics is performed based on the value of change in heat transfer rate at the time of high output with respect to that at the time of low output, improved value thereof, improvement rate in heat transfer rate, and a temperature difference max- min ΔT and improved value thereof.

[0044] The value of change in heat transfer rate represents a value expressed in percentage by dividing an

overall heat transfer rate at high output by the overall heat transfer rate at low output and subsequently subtracting 1 from the divided value (see Equation (6) in Figure 7). The overall heat transfer rate is the sum of the heat transfer rates of surfaces A through F (see Equation (7) in Figure 7). The improved value of the rate of heat transfer rate at high output with respect to that at low output relates to the change of value of heat transfer rate at high output with respect to that for low output and is obtained by subtracting 1 from the values in each of the embodiments (see Equation (7) in Figure 7).

[0045] The improvement rate in heat transfer rate is obtained, after subtracting the overall heat transfer rate at high output in the first Comparative Example from the overall heat transfer rate at high output for each embodiment, dividing the subtraction result by a number of disposed surfaces (see Equation 8 in Figure 7). The number of disposed surfaces denotes the number of surfaces on which the first cover layer is applied or arranged.

[0046] The temperature difference max-min ΔT relates the temperature difference among surfaces A to F at high output power and is obtained by subtracting the min. value from the max. value (see Equation) in Figure 7). The improvement rate in the temperature difference, max-min ΔT relates to the temperature difference max-min ΔT and is obtained by first subtracting the value for each embodiment from the value in the first Comparative Example and subsequently dividing by the number of disposed surfaces (see Equation 10 in Figure 7).

[0047] As shown in Figure 7, according to the first embodiment (first cover layer is disposed on the side supporting surface C), the changed value for heat transfer rate change during the high power to low output is better than Comparative Example 1, and the improvement value thereof represents the difference of approximately 3 percents. Since the heat transfer q per unit area by radiation heat transfer is considered to be proportional to the fourth power of the absolute temperature difference, the heat transfer rate is indicated as being dependent on the temperature.

[0048] That is, when the battery module is supported by the bracket, the heat transfer between the battery module and the battery case is dominant through convective and radiative heat transfer, the heat transfer may be determined by the sum of the convection heat transfer (Equation 1 in Figure 2) and radiative heat transfer (Equation 2 in Figure 2). Thus, when at receiving heat of outside air (temperature region where heat receiving takes place from ambient air), since the heat transfer effect by radiation is small, the same level of heat transfer rate (heat resistance) is shown as that of Comparative Example 1, while at high output (during use at high temperature), since the radiative heat transfer effects will be larger such that the heat transfer rate is considered to increase compared to Comparative Example 1.

[0049] According to the second embodiment (first coating layers on all surfaces A to F), the improvement value of heat transfer rate change value at high output with

respect to that for low output represents about 15 points difference and shows the maximum value among the first to fourth embodiments. This is considered in such a way that the improvement over the entire outside surfaces of battery module and the entire inner surface of the case will maximize the heat dissipation during use at high temperature.

[0050] According to the third embodiment (first coating layer disposed on planes E and F is representing a non-supporting side surface), the improvement rate in heat transfer rate is 1.35 points and indicates the maximum value among the first to fourth embodiments. This is due to the surface E and surface F being the surface with large heat transfer rate during use at high temperature and thus representing the portion showing the maximum change in heat resistance at high temperature with respect to that at low temperature. Therefore, the improvement magnitude is the highest. Note that the large heat transfer rate at surfaces E, F during use at high temperature is considered to be the effects of great heat rise (convection heat transfer) in addition to the radiative heat transfer.

[0051] According to the fourth embodiment (top surface, A is disposed with first cover layer), the improvement value in temperature difference, max-min ΔT is about 5 °C, and thus indicates the maximum value among the first to fourth embodiments. Surface A is a surface with low heat transfer rate during use at high temperature (at high output) and thus is considered to be the surfaces whose temperature will be high due to heat increase (convection heat transfer) such that the improvement level in temperature variations among surfaces is the greatest.

[0052] As described above, in the present embodiments, because a cover layer having an emissivity or radiation coefficient higher than that of the associated base material is provided between the outer surface of the battery module and the inner surface of case, the heat dissipation property is increased and the battery or cell subject to high temperature due to heat by power generation may secure the dissipation performance. In addition, a space is formed between the outer surface of the battery module and the inner surface of the case is provided so as the heat receiving property is reduced. Thus, the increase in cell temperature due to heat received during the day time where the ambient temperature is higher than the battery temperature during non-use. Therefore, by securing dissipation performance during use (power generation) while reducing the heat receiving property during non-use (no power generation), the temperature of battery or cell may be held low and a battery case or an attachment structure of battery to the case may be provided, which is capable of suppressing battery capacity decrease due to thermal degradation.

[0053] Further, when the first cover layer and the second cover layer are disposed on the entire outer surface of the battery module and the entire inner surface of the cell first, respectively, the entire surface emissivity is improved over the entire surface of the inner surface of the

case and the entire surface of the outer surface of the battery module, it is possible to maximize the heat dissipation when used in high temperature.

[0054] When arranging the first cover layer to the wall surface portion of the battery module, and with respect to the direction of gravity, the battery case is configured such that one of the opposing surfaces is positioned above and the other positioned below, the wall surface disposed by the first cover layer represents the portion of maximum change in thermal resistance at high temperature with respect to that at low temperature, the effects per unit area of application will be the highest. In addition, when the first cover layer is disposed on the non-supporting surface of the wall surface portions, interference with dissipation performance will be preferably avoided due to the presence of the bracket.

[0055] When the first cover layer is arranged on the one of a pair of the opposing surfaces of a battery module, and with respect to the direction of gravity, the one of the opposing surfaces applied with the first cover layer is positioned above while the other one of the opposing surfaces is positioned below to configure the battery case, since the one of the pair of the surfaces represents the position at the highest temperature, the average temperature may be decreased with the variations in temperature among positions (surfaces) being reduced so that the effects per unit area of the first and second cover layers will be the highest.

[0056] When configuring the battery module by arranging side by side, depending on disposing cells in series and/or parallel fashion, a battery pack with a desired current, voltage, and capacity may be formed.

[0057] The present invention is not limited to the specific embodiments described above. Rather, within the scope of claims, various alterations or modifications are possible. For example, the battery module is not limited to the configuration in which a plurality of containers housing a plurality of cells are disposed side by side, but is applicable to the configuration in which the cell is not accommodated within a container. In this case, for example, the exterior material is disposed with a first cover layer. In addition, the battery case is not limited to the configuration for mounting to a vehicle. Further, the battery is not limited to a lithium-ion secondary battery, but is applicable to a nickel hydrogen secondary battery as well.

[0058] The present application is based on the Japanese Patent Application, No. 2011-031005 filed February 16, 2011, and the disclosure of this Application is referred to and incorporated herein in its entirety

DESCRIPTION OF REFERENCE SIGNS

[0059]

100	Battery case
120	Case body
124	Second cover layer

140	Bracket (support means),			wall surface has a supporting surface on which the supporting mechanism is attached and a non-supporting surface disposed with the first cover layer.
160	Lid portion			
180	Battery module			
180A	Dummy battery module			
182	cell or battery	5	5.	The battery case as claimed in claim 1, wherein the battery module has a pair of relatively opposing surfaces and a wall surface connecting the pair of opposing surfaces, and
182A	Rubber heater			the first cover layer is disposed on the one of the pair of the opposing surfaces.
184	First cover layer			
186	Insulating material			
190	Vehicle			
Surface A	(Top surface: one of a pair of opposing surfaces)	10		
Surface B	(Bottom surface: the other of the pair of the opposing surfaces)		6.	The battery case as claimed in any one of claims 1 to 5, wherein
Surface C	(Wall surface portion: one of a pair of supporting wall surfaces)	15		the battery module is configured to be composed of a plurality of containers side by side each housing a plurality of cells.
Surface D	(Wall surface portion: the other of the pair of supporting wall surfaces)			
Surface E	(Wall surface portion: one of a pair of non-supporting wall surfaces)		7.	A mounting structure to a battery case that accommodates a battery module having at least one cell, wherein the battery case comprises:
Surface F	(Wall surface portion: the other of the pair of non-supporting wall surfaces)	20		
S	Space			a supporting mechanism for supporting the battery module, thereby forming a space between the outer surface of the battery module and inner surface of the case,
Claims		25		a first cover layer disposed on the outer surface of the battery module and having a higher thermal radiation emissivity than that of the outer surface of the battery module, and
1.	A battery case which houses a battery module having at least one cell, comprising:			a second cover layer disposed on the inner surface of the case having a higher radiation emissivity than that of the inner surface of the case, wherein
	a supporting mechanism for supporting the battery module, thereby forming a space between the outer surface of the battery module and inner surface of the case,	30		the first cover layer and the second cover layer are opposed to each other at least partly through the space,
	a first cover layer disposed on the outer surface of the battery module and having a higher thermal radiation emissivity than that of the outer surface of the battery module, and	35		the battery module has a pair of opposing surfaces opposed to each other and a wall surface which connects the pair of opposing surfaces, the first cover layer is disposed on the one of the pair of opposing surfaces, and wherein,
	a second cover layer disposed on the inner surface of the case having a higher radiation emissivity than that of the inner surface of the case, wherein	40		with respect to the direction of gravity, the one of the pair of the opposing surfaces disposed with the first cover layer is positioned above while the other of the pair of opposing surfaces is positioned below so as to be attached to the battery case.
	the first cover layer and the second cover layer are opposed to each other at least partly through the space.	45		
2.	The battery case as claimed in claim 1, wherein the first cover layer and the second cover layer are disposed on the entire outer surface of the battery module and the entire inner surface of the case, respectively.	50	8.	The mounting structure as claimed in claim 7, wherein
3.	The battery case as claimed in claim 1, wherein the battery module has a pair of opposing surfaces and a wall surface connecting the pair of opposing surfaces, and	55		the wall surface has a supporting side surface on which the supporting mechanism is attached and a non-supporting surface on which the first cover layer is disposed.
	the first cover layer is disposed on the wall surface.		9.	A mounting structure to a battery case of sealed structure that accommodates a battery module having at least one cell, wherein
4.	The battery case as claimed in claim 3, wherein the			

the battery case comprises:

a supporting mechanism for supporting the battery module and forming a space between the outer surface of the battery module and the inner surface of the case, 5
 a first cover layer disposed on the outer surface of the battery module and having a higher thermal radiation emissivity than that of the outer surface of the battery module, and 10
 a second cover layer disposed on the inner surface of the case having a higher radiation emissivity than that of the inner surface of the case, wherein 15
 the first cover layer and the second cover layer are opposed to each other at least partly through the space, 20
 the battery module has a pair of opposing surfaces to each other and a wall surface which connects the pair of opposing surfaces, wherein 25
 the first cover layer is disposed on the one of the pair of opposing surfaces, and, 30
 with respect to the direction of gravity, the one of the pair of the opposing surfaces disposed by the first cover layer is positioned above while 35
 the other of the pair of opposing surfaces is positioned below so as to be attached to the battery case. 40

10. The mounting structure as claimed in any one of claims 7 to 9, wherein the battery module is configured by arranging a plurality of containers side by side each housing a plurality of cells. 45

50

55

60

65

70

FIG. 1

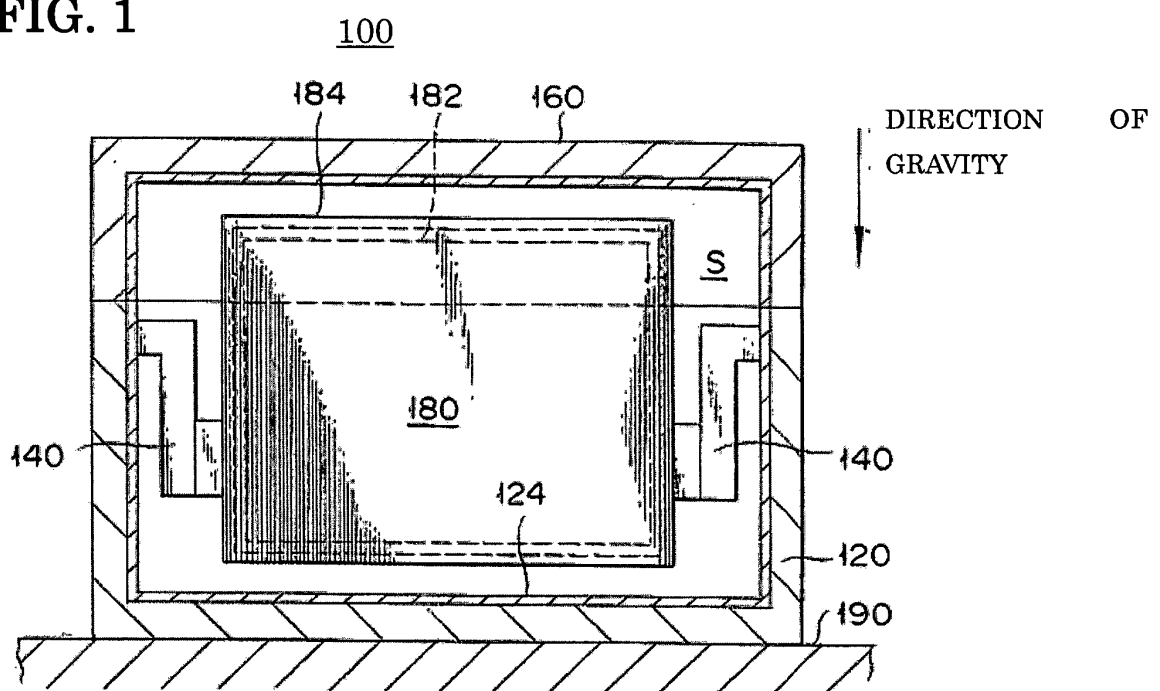
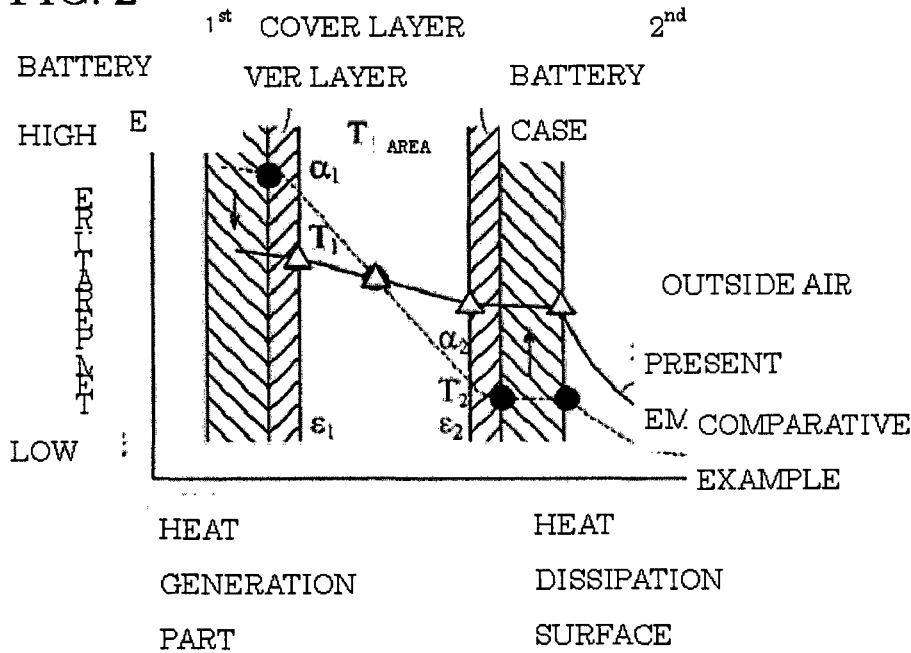


FIG. 2



EQUATION 1: CONVECTIVE HEAT TRANSFER

FIG. 2

$$q = \alpha_1 \cdot (T_1 - T_{\text{AREA}})$$

$$\alpha_1 = 0.54 \cdot (\text{Gr} \cdot \text{Pr})^{1/4} \cdot \lambda / L$$

EQUATION 2: RADIATIVE HEAT TRANSFER

$$q = \frac{\sigma (T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1}$$

- | | |
|---|---|
| q : HEAT TRANSFER AMOUNT PER UNIT AREA | Pr : PRANDTLE NUMBER |
| α_1 : HEAT TRANSFER RATE | λ : HEAT CONDUCTIVITY |
| T_1 : ABS. TEMP OF OUTER SURFACE OF BAT. MODULE | L : REPRESENTATIV LENGTH OF HEAT TRANS SURFACE |
| T_2 : ABS. TEMP OF INNER SURFACE OF BAT. MODULE | σ : STEPHAN-BOLTZMANN'S CONST. |
| T_{AREA} : ABS. TEMP OF AREA | ϵ_1 : EMISSIVITY OF OUTER SURFACE OF BAT. MODULE |
| Gr : GRASHOF NUMBER | ϵ_2 : EMISSIVITY OF INNER SURFACE OF BAT. MODULE |

FIG. 3

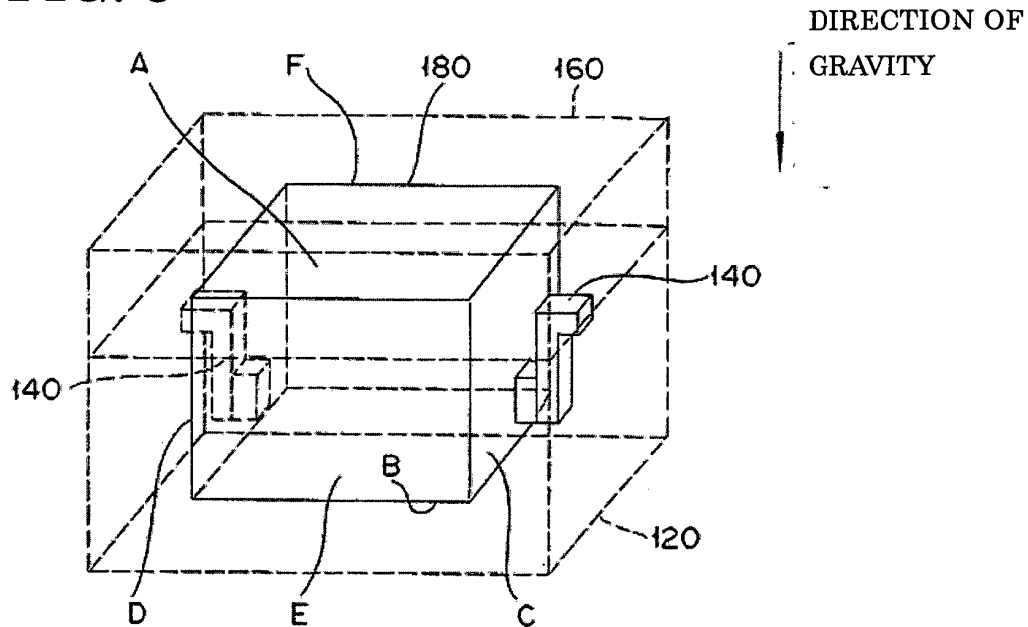


FIG. 4

	DISPOSED SURFACE WITH FIRST COVER LAYER	NUMBER OF DISPOSED SURFACES	HEAT TRANSFER RATE WHEN RECEIVING OUTSIDE AIR TEMP. (W/m ² · K, TEMP°C) EQ.3						
			SURFACE A (TOP SURFACE)	SURFACE B (BOTTOM SURFACE)	SURFACE C (SUPPORT SURFACE)	SURFACE D (SUPPORT SURFACE)	SURFACE E (NON-SUPP SURFACE)	SURFACE F (NON SUPP SURFACE)	OVERALL (EQ. 4)
1st EMBODIMENT	SURFACE C	1	3.0	3.4	4.1	3.4	3.3	3.3	20.5
2nd EMBODIMENT	ALL SURFACES	6	3.7	4.0	4.1	4.0	4.0	4.1	23.8
3rd EMBODIMENT	SURFACES E, F	2	3.0	3.4	3.5	3.4	4.0	4.1	21.3
4th EMBODIMENT	SURFACE A	1	3.7	3.4	3.5	3.4	3.3	3.3	20.6
COMPARATIVE EXAMPLE 1	NOT DISPOSED, SAME STRUCTURE AS EMBODIMENT	0	3.0	3.4	3.5	3.4	3.3	3.3	19.9
COMPARATIVE EXAMPLE 2	NOT DISPOSED, SURFACE B IN CONTACT (ATTACHED)	0	3.0	15.0	3.5	3.4	3.3	3.3	31.5

EQ. 3) HEAT TRANSFER RATE (W/m²· K) = OUTPUT DENSITY (EQ.6)/ (DUMMY BAT. MODULE TEMP. - OUTSIDE AIR TEMP.)

EQ. 4) OVERALL HEAT TRANSFER RATE (W/m²· K) = SURFACE A HEAT TRANSFER RATE + SURFACE B HEAT TRANSFER RATE + ... SURFACE F HEAT TRANSFER RATE

EQ. 6) OUTPUT DENSITY(W/m2) = OUTPUT (W)/ AREA (m²)

FIG. 5									
	DISPOSED SURFACE WITH FIRST COVER LAYER LAYER	NUMBER OF DISPOSED SURFACES	HEAT TRANSFER RATE AT HIGH OUTPUT (70 °C) (W/m ² · k, TEMP°C)						
			SURFACE A (TOP SURFACE)	SURFACE B (BOTTOM SURFACE)	SURFACE C (SUPPORT SURFACE)	SURFACE D (SUPPORT SURFACE)	SURFACE E (NON-SUPP SURFACE)	SURFACE F (NON SUPP SURFACE)	OVERALL
1st EMBODIMENT	SURFACE C	1	3.1	3.5	4.7	3.4	3.4	3.4	21.5
2nd EMBODIMENT	ALL SURFACES	6	4.3	4.7	4.7	4.7	4.7	4.8	27.9
3rd EMBODIMENT	SURFACES E, F	2	3.1	3.5	3.5	3.4	4.7	4.8	23.0
4th EMBODIMENT	SURFACE A	1	4.3	3.5	3.5	3.4	3.4	3.4	21.5
COMPARATIVE EXAMPLE 1	NOTDISPOSED, SAME STRUCTURE AS EMBODIMENT	0	3.1	3.5	3.5	3.4	3.4	3.4	20.3
COMPARATIVE EXAMPLE 2	NOT DISPOSED, SURFACE B IN CONTACT (ATTACHED)	0	3.1	15.0	3.8	3.5	3.4	3.4	32.0

FIG. 6									
	DISPOSED SURFACE WITH FIRST COVER LAYER LAYER	NUMBER OF DISPOSED SURFACES	ACTUAL TEMP. AT HIGH OUTPUT (70 °C) (°C)						
			SURFACE A (TOP SURFACE)	SURFACE B (BOTTOM SURFACE)	SURFACE C (SUPPORT SURFACE)	SURFACE D (SUPPORT SURFACE)	SURFACE E (NON-SUPP SURFACE)	SURFACE F (NON SUPP SURFACE)	
	1st EMBODIMENT	SURFACE C	1	76.5	68.6	60.6	68.5	68.5	68.6
	2nd EMBODIMENT	ALL SURFACES	6	64.2	61.0	60.6	61.0	60.6	60.3
	3rd EMBODIMENT	SURFACES E, F	2	76.5	68.6	67.4	68.5	60.6	60.3
	4th EMBODIMENT	SURFACE A	1	64.2	68.6	67.4	68.5	68.5	68.6
	COMPARATIVE EXAMPLE 1	NOTDISPOSED, SAME STRUCTURE AS EMBODIMENT	0	76.5	68.6	67.4	68.5	68.5	68.6
	COMPARATIVE EXAMPLE 2	NOT DISPOSED, SURFACE B IN CONTACT (ATTACHED)	0	76.0	58.0	66.5	67.2	67.7	67.3

FIG. 7

	DISPOSED SURFACE	NUMBER OF DISPOSED SURFACES	HEAT TRANSFER RATE (W/m ² · °C) TEMP. DIFFERENCE EVALUATION RESULTS	IMPROVE RATE			TEMP. DIFFERENCE E	IMPROVE VALUE
				IN HEAT TRANSFER				
				RATE (EQ. 9)				
				VALUE (EQ. 9)	IMPROVE VALUE (EQ. 9)	RATE (EQ. 9)	EQ. 9	EQ. 10
1st EMBODIMENT	SURFACE C	1	6	3.4	1.2	16.47		
2nd EMBODIMENT	ALL SURFACES	6	17.2	18.2	1.2	4		0.8
3rd EMBODIMENT	SURFACES E, F	2	7.3	8.1	1.36	10.24		
4th EMBODIMENT	SURFACE A	1	4.2	2.2	1.9	4.4		4.1
COMPARATIVE EXAMPLE STRUCTURE AS EMBODIMENT	NOT DISPOSED, SAME STRUCTURE AS EMBODIMENT	0	1.5				9.4	
COMPARATIVE EXAMPLE SURFACE B IN CONTACT (ATTACHED)	NOT DISPOSED, SURFACE B IN CONTACT (ATTACHED)	0	1.6				10	

EQ. 8 CHANGE IN HEAT TRANSFER RATE AT HIGH OUTPUT/LOW OUTPUT =
OUTPUT/LOW OUTPUT/HEAT TRANSFER RATE AT HIGH OUTPUT/LOW OUTPUT - 0.1 X 100

EQ. 7 IMPROVEMENT VALUE IN HEAT TRANSFER RATE CHANGE AT HIGH OUTPUT/LOW OUTPUT = CHANGE VALUE IN HEAT TRANSFER RATE AT HIGH OUTPUT/LOW OUTPUT IN EMBODIMENT - CHANGE VALUE IN HEAT TRANSFER RATE AT HIGH OUTPUT/LOW OUTPUT IN COMPARATIVE EXAMPLE

EQ. 6 IMPROVEMENT RATE IN HEAT TRANSFER RATE = (OVERALL HEAT TRANSFER RATE AT HIGH OUTPUT IN EMBODIMENT - OVERALL HEAT TRANSFER RATE AT HIGH OUTPUT IN COMPARATIVE EXAMPLE) / NUMBER OF DISPOSED SURFACES

EQ. 5 TEMP. DIFFERENCE (mm/mb) AT VALUE = HIGH OUTPUT (SURFACES A AND F) TEMP. DIFFERENCE (mm/mb) VALUE - HIGH OUTPUT (SURFACE B AND D) TEMP. DIFFERENCE (mm/mb) VALUE

EQ. 4 IMPROVEMENT RATE IN TEMP. DIFFERENCE (mm/mb) AT VALUE = (TEMP. DIFFERENCE (mm/mb) AT VALUE IN COMPARATIVE EXAMPLE - TEMP. DIFFERENCE (mm/mb) AT VALUE IN EMBODIMENT) / NUMBER OF DISPOSED SURFACES

FIG. 8

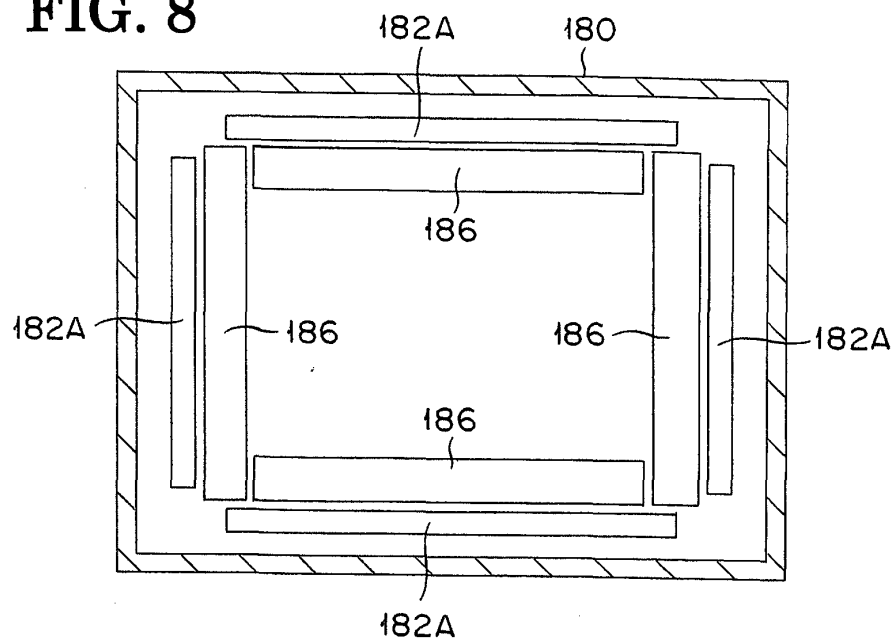


FIG. 9

COMPARATIVE EXAMPLE 1

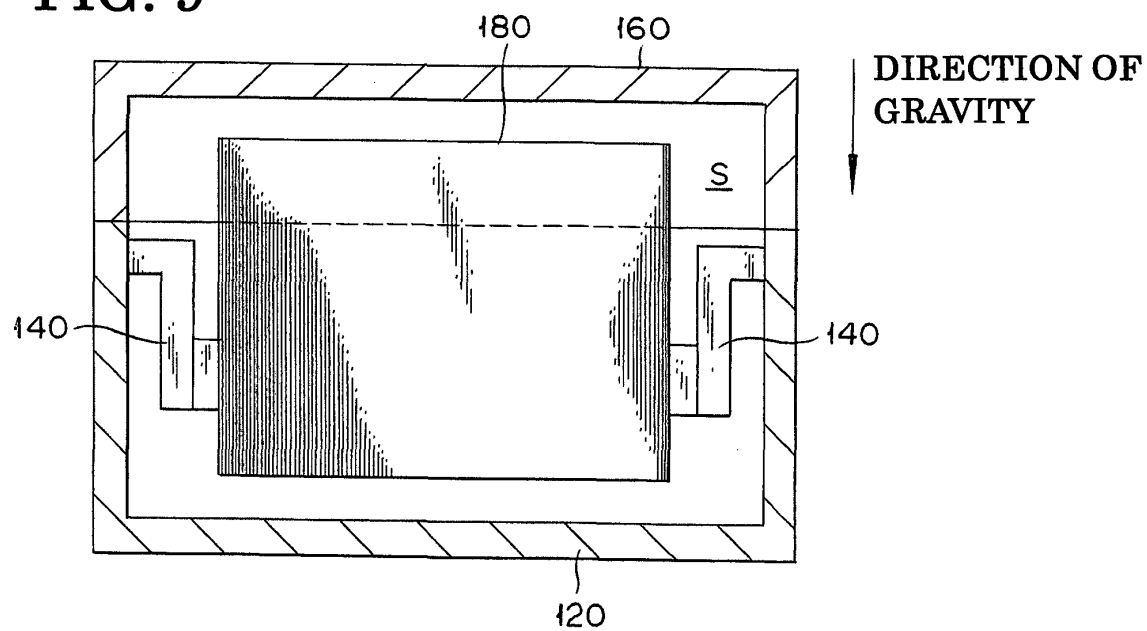
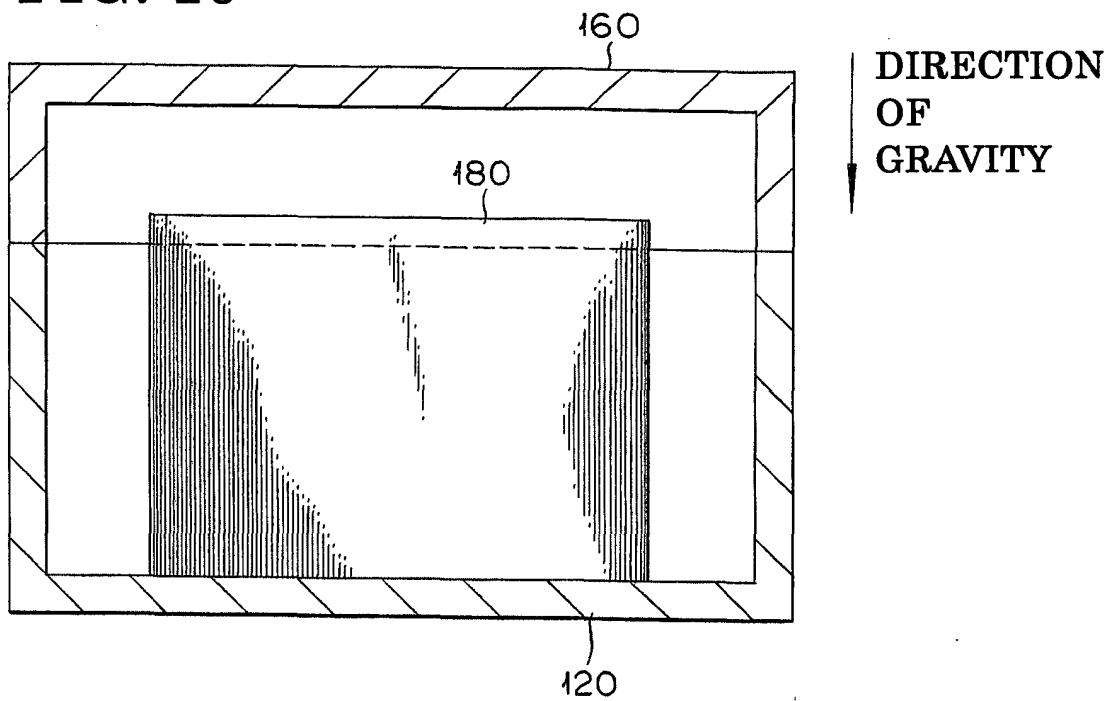


FIG. 10

COMPARATIVE EXAMPLE 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/079102

A. CLASSIFICATION OF SUBJECT MATTER

H01M10/50(2006.01) i, H01M2/10(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01M10/50, H01M2/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012

Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2009-259748 A (Toyota Motor Corp.), 05 November 2009 (05.11.2009), claims; fig. 2 (Family: none)	1-3, 5-6 4, 7-10
Y	JP 2007-134308 A (Sony Corp.), 31 May 2007 (31.05.2007), claims; fig. 2 (Family: none)	1-3, 5-6
Y	JP 2009-295381 A (Toshiba Corp.), 17 December 2009 (17.12.2009), claims; fig. 1 to 2 (Family: none)	1-3, 5-6

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
30 January, 2012 (30.01.12)Date of mailing of the international search report
07 February, 2012 (07.02.12)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/079102

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-308812 A (Matsushita Electric Industrial Co., Ltd.), 31 October 2003 (31.10.2003), claims (Family: none)	1-3, 5-6
Y	JP 2008-300088 A (Toyota Motor Corp.), 11 December 2008 (11.12.2008), claims; paragraphs [0025] to [0038]; fig. 2 (Family: none)	1-3, 5-6
Y	JP 63-175355 A (Kawasaki Heavy Industries, Ltd.), 19 July 1988 (19.07.1988), claims; fig. 1 (Family: none)	1-3, 5-6
P, X	JP 2011-210619 A (Sanyo Electric Co., Ltd.), 20 October 2011 (20.10.2011), claims; paragraph [0096]; fig. 2 (Family: none)	1-3, 5-6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2004304881 A [0003]
- JP H10333782 B [0003]
- JP 2008130729 A [0003]
- JP 2011031005 A [0058]